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ORIGINAL ARTICLE

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Titanium cages in the surgical treatment of severe vertebral osteomyelitis

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This article is dedicated to Professor Dr. Winfried Winkelmann, Head of the Department of Orthopedics, University Hospital of Münster, on the occasion of his 60th birthday, with best wishes and many thanks for all his support.

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Abstract The role of spinal implants in the presence of infection is critically discussed. In this study 20 patients with destructive vertebral osteomyelitis were surgically treated with one-stage posterior instrumentation and fusion and anterior debridement, decompression and anterior column reconstruction using an expandable titanium cage filled with morsellised autologous bone graft. The patients' records and radiographs were retrospectively analysed and follow-up clinical and radiographic data obtained. At a mean follow-up of 23 months (range 12–56 months) all cages were radiographically fused and all infections eradicated. There were no cases of cage dislocation, migration or subsidence. Local kyphosis was corrected from 9.2° (range –20° to 64°) by 9.4° to –0.2° (range –32° to 40°) postoperatively and lost 0.9° during follow-up. All five patients with preoperative neurological deficits improved to Frankel score D or E. Patient-perceived disability caused by back pain averaged 7.9 (range 0–22) in the Roland–Morris score at follow-up. In cases of vertebral osteomyelitis with severe anterior column destruction the use of titanium cages in combination with posterior instrumentation is effective and safe and offers a good alternative to structural bone grafts. Further follow-up is necessary to confirm these early results.

Keywords Vertebral osteomyelitis · Spinal infection · Spondylodiscitis · Cages · Spinal fusion

Introduction

Whereas early stages of vertebral osteomyelitis commonly respond to conservative treatment [2, 18], more advanced conditions with marked spinal instability, epidural or paraspinal abscesses and neurological deficits require surgical decompression, stabilisation and reconstruction of the anterior column. The reported techniques of surgical treatment range from anterior debridement and interbody fusion [13], debridement and internal fixation from the posterior approach [17] to combined single-stage or two-stage posterior instrumentation with anterior debridement and bone grafting [1, 5, 7, 8, 11, 14, 15, 19]. Anterior instrumentation or the use of cages has been anecdotally reported, but there is a critical discussion concerning the role of spinal implants in the presence of infection [4, 8, 19, 21].

For the surgical treatment of vertebral osteomyelitis with severe anterior column destruction we started using titanium cages for anterior reconstruction in addition to posterior stabilisation in 1998. We hypothesised that an expandable titanium ring cage would offer better primary stability and reliable correction of the sagittal plane deformity, simultaneously avoiding the donor site morbidity of structural autologous bone graft harvesting. In the current literature the only publication on the use of cages in the surgical treatment of pyogenic vertebral osteomyelitis has been provided by Hee et al. [18], who reported on four

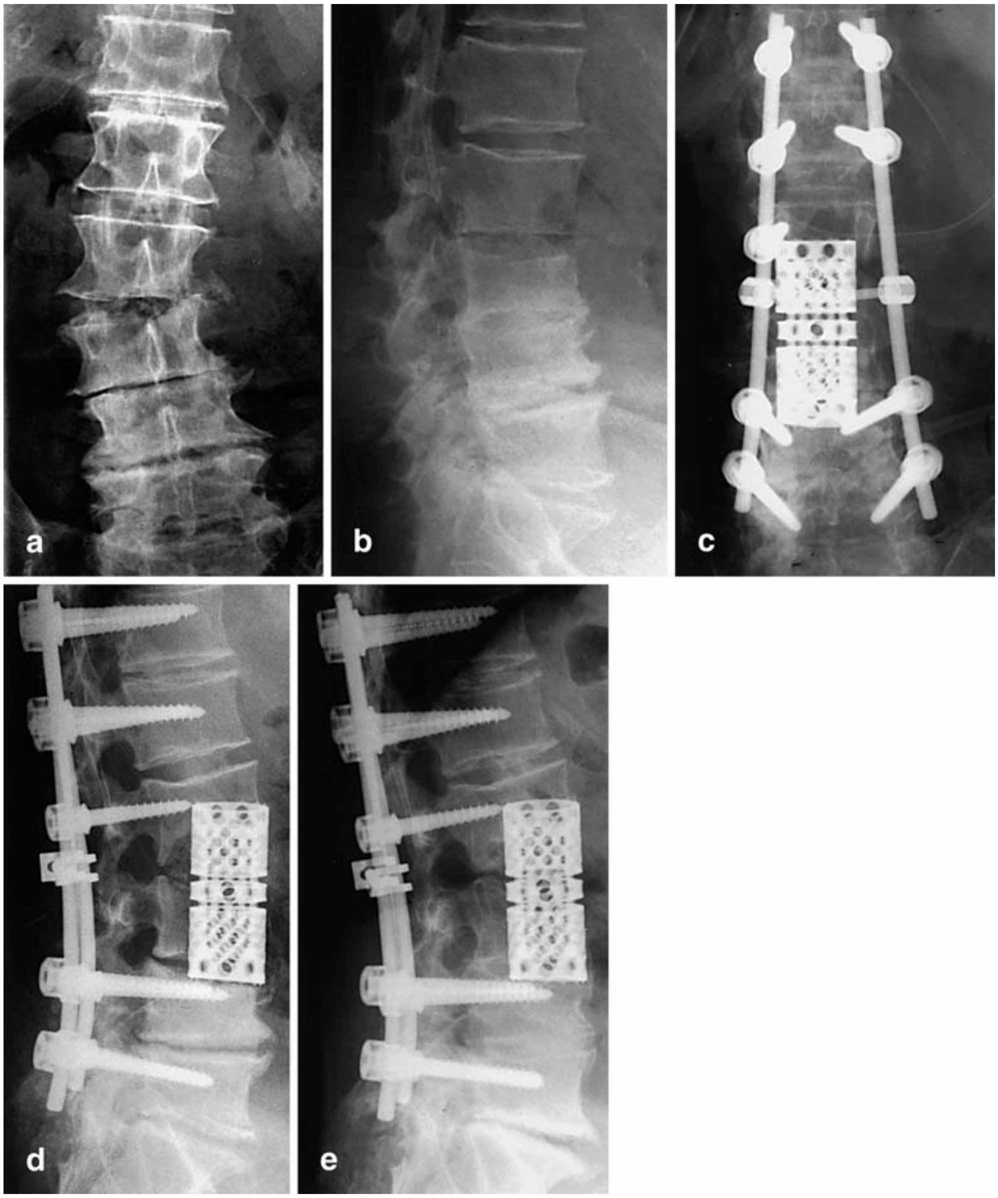

Fig. 1a–e An 80-year-old male (patient number 9) with vertebral osteomyelitis and destruction of L3 and marked frontal and sagittal plane deformity (**a**, **b**), treated with one-stage posterior transpedicular stabilisation of T12–L5, anterior subtotal corpectomy of L3 and reconstruction with an expandable titanium cage was performed. Postoperative X-rays (**c**, **d**) demonstrate good frontal and sagittal plane correction, but a lucent line at the distal cage – bone interface. At 22 months follow-up (**e**) the lucent line has disappeared, with radiographically fused interfaces and initial bony incorporation of the cage

cases treated with posterior stabilisation and anterior fusion with titanium mesh cages. The aim of the present study was to evaluate the clinical and radiographic results of 20 patients with severe vertebral osteomyelitis treated with this technique.

Material and methods

Between 1998 and 2002, 20 patients with severely destructive vertebral osteomyelitis were surgically treated with posterior stabilisation, anterior debridement and anterior column reconstruction using an expandable titanium ring cage at our institution. Average age was 68.0 years (range 51–83 years); 12 patients were female and 8 male. The medical records were retrospectively reviewed and all patients (except for 3 who had died) were examined and anteroposterior and lateral X-rays were obtained. Follow-up averaged 23 months (range 12–56 months). The data collection included concurrent pathological conditions, preoperative neurological status (Frankel score [6]) and intraoperative complications as well as blood loss and isolated organisms. Postoperative complications and duration of intravenous and oral antibiotic therapy as well as duration of postoperative bed rest were noted.

The radiographic analysis included preoperative, postoperative and late frontal and sagittal plane deformity, measured as the Cobb angle [3]. The lateral Cobb angle was measured as local kyphosis (of the affected segment), kyphosis at fusion levels and the regional sagittal profile (lumbar lordosis L1–L5, thoracolumbar junction T10–L2, thoracic kyphosis T4–T12). On the most recent X-rays any screw lucencies were recorded and the bone–cage interfaces evaluated. The cage was judged as fused if there were no lucencies at the bone–cage interfaces. Bony incorporation of the cage was assessed as complete if there was a continuous bony fusion mass either anterior or posterior to the cage and as incomplete

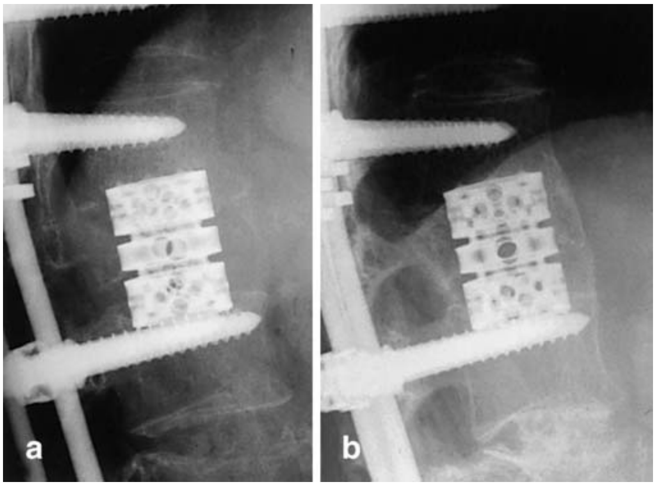

Fig. 2a, b A 71-year-old male (patient number 5) with destructive vertebral osteomyelitis of L1, treated with one-stage posterior transpedicular stabilisation and anterior corpectomy L1 and reconstruction with expandable titanium cage (**a**). **b** Fifty-six months postoperatively there is complete bony incorporation of the cage with complete anterior bony bridging

if the bony fusion extended beyond the interface levels but without complete coverage of the cage (Figs. 1, 2, 3). At the follow-up visit the German version of the Roland–Morris score (0=no back-pain-related disability; 24=maximum back-pain-related disability) was applied to evaluate the patient-perceived disability caused by back pain [20] and the current neurological status was recorded.

Surgical technique

All patients were operated on in a single session. First, a multisegmental posterior fixation and fusion was performed with, usually, transpedicular fixation techniques (Micomed Posterior Dual Rod System, Micomed Ortho, Unteraegeri, Switzerland) and cancellous autologous bone from the posterior iliac crest. Patient positioning and appropriate rod bending enabled correction of the, in most cases, flexible sagittal plane deformity. The fusion levels were chosen depending on the quality of bone and the extent of the anterior defect, most commonly two segments above and below the infected segment. In cases where epidural abscess was present, this was decompressed, irrigated and drained from posteriorly (Fig. 4). The patient was then placed in a lateral position. If an extensive paraspinal abscess was present, this side was chosen for the approach; otherwise the midthoracic spine was approached from the right side and the thoracolumbar and lumbar spine from the left. A thorough debridement with resection of all infected and necrotic tissue was performed. Tissue specimens were sent for microbiolog-

Fig. 3a–d A 63-year-old female (patient number 11) with vertebral osteomyelitis and destruction of L3. **a**, **b** Considerable spinal canal encroachment by infectious debris can be seen. The patient underwent one-stage posterior stabilisation of L1–L5 and anterior corpectomy, spinal canal decompression and reconstruction with expandable titanium cage. **c**, **d** Follow-up X-rays after 6 months. Slight lucencies are visible around the pedicle screws in L5 (**c**)

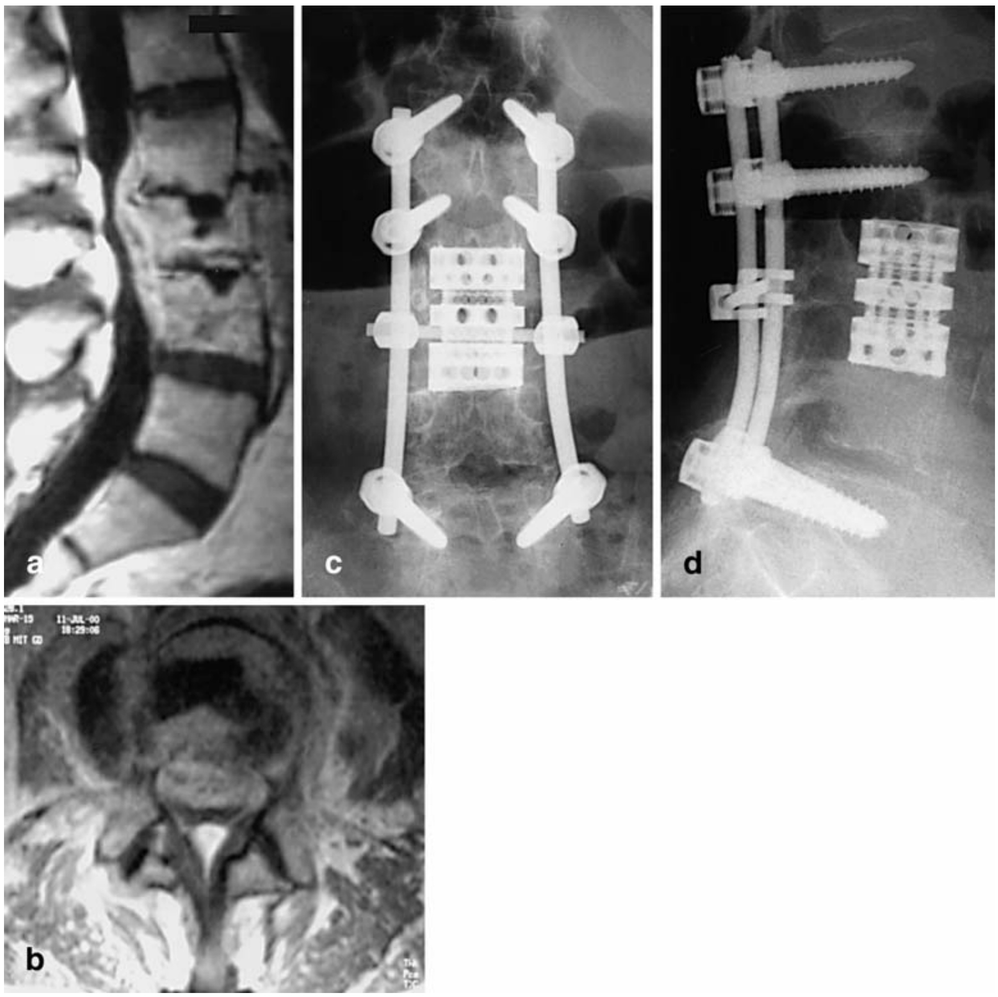

Fig. 4a–d A 55-year-old female (patient number 6) with diabetes mellitus and severe vertebral osteomyelitis with complete destruction of L3 and an extensive epidural abscess from T11 down to S1 (*, **a**, **b**) and bilateral psoas abscesses (*, **c**). Treatment by one-stage posterior transpedicular stabilisation T12–L5 and posterior drainage of the epidural abscess via multilevel flavotomies, L3 anterior corpectomy with drainage of the psoas abscesses, and anterior column reconstruction with an expandable titanium cage. Lateral X-ray at 26 months' follow-up visit (**d**) demonstrates solid interbody fusion and anterior bony coverage of the cage. The infection was eradicated without further revisions

ical and pathological analysis. Spinal decompression was achieved by complete clearance of the spinal canal of any infectious debris (Fig. 3). After extensive irrigation of the wound with an antimicrobial agent, the titanium ring cage (Vertebral Body Replacement, Ulrich GmbH, Ulm, Germany), filled with morsellised autologous bone, was introduced and expanded until solidly locked (Fig. 1, 2, 3, 4). Before wound closure, an antibiotic collagen sponge (Sulmycin Implant, Nycomed Pharma, Unterschleissheim, Germany) was placed around the cage and a deep drain inserted.

Results

Clinical data

The clinical data are shown in Table 1. Average total operation time was 340 min (range 210–540 min). Intraoperative blood loss averaged 1965 ml (range 500–9600 ml), with a median of 1400 ml. Preoperative C-reactive protein averaged 7.2 mg/dl (range 0.7–9.3 mg/dl) and was normal (<0.5 mg/dl) at follow-up in all but 9 patients. These 9 patients (average C-reactive protein at follow-up: 1.3 mg/dl, range 0.7–2.3 mg/dl) had concomitant medical disorders such as rheumatoid arthritis, lupus erythematosus, diabetes mellitus, renal insufficiency, chronic pancreatitis or monoclonal gammopathy. Three patients died during follow-up. Patient number 18 (82 years old with severe cardiopulmonary insufficiency) developed pneumonia and died 3 weeks postoperatively of cardiopulmonary failure. Patient number 19 (72 years old with acute myelodepression secondary to an overdose of methotrexate) died 14 weeks postoperatively of multiorgan failure. Patient number 15 died 24 months postoperatively of myocardial infarction and had not attended any short- or medium-term follow-up visits. All patients' concomitant medical disorders are listed in Table 2.

Patient-perceived disability caused by back pain averaged 7.9 (median 6.5, range 0–22) in the Roland-Morris score at follow-up. Patient number 17 was mentally not capable of answering the questionnaire. Multivariant analysis of the clinical and radiographic data revealed a worse functional outcome (Roland-Morris score >10) for those

Table 1 Clinical data of all patients (*RMS* Roland–Morris score at follow-up)

Patient no.	Patient age	Patient sex	Follow-up[a]	Organisms isolated	Frankel score preoperatively	Frankel score at follow-up	RMS**
1	77	f	12	*Candida albicans*	E	E	17
2	71	f	12	*Serratia marcescens*	E	E	12
3	83	f	18	*Mycobacterium tuberculosis*	E	E	1
4	61	f	12	*Mycobacterium fortuitum*	E	D	14
5	71	m	56	*Staph. aureus*	E	E	17
6	55	f	26	*Staph. aureus*	D	E	1
7	58	f	38	*Proteus mirabilis, Pseudomonas aeruginosa*	E	E	6
8	69	f	30	*Enterococcus faecalis*	E	E	11
9	80	m	22	*Peptostreptococcus* sp.	D	E	7
10	51	f	24	*Staph. aureus*	E	E	0
11	63	f	26	*E. coli*	E	E	22
12	55	f	12	*Enterococcus faecalis*	E	E	1
13	71	f	12	*Mycobacterium tuberculosis*	E	E	15
14	65	m	16	*Staph. aureus*	B	D	1
15	70	f	–	*Mycobacterium tuberculosis*	C	–	–
16	71	m	28	*Staph. aureus*	B	E	0
17	52	m	27	*Staph. aureus*	B	E	–
18	82	m	–	*Enterococcus faecalis*	E	–	–
19	72	m	–	*Staph. aureus*	–	–	–
20	69	m	12	–	E	E	1

[a]In months

Table 2 List of concomitant medical disorders of all patients

Concomitant medical disorder	Number of patients
Arterial hypertension	14
Renal insufficiency	7
Diabetes mellitus	6
Cardiac insufficiency	6
Cardiac arrhythmia	6
Chronic obstructive pulmonary disease	2
Rheumatoid arthritis	1
Lupus erythematosus	1
Myelodepression	1
Monoclonal gammopathy	1
Pancreatitis	1

patients in whom the lumbar spine was affected, those with a hyperkyphotic thoracolumbar junction at follow-up and those with lucencies around the pedicle screws.

Average duration of postoperative intravenous antibiotic therapy was 28 days (range 13–57 days, median 21 days). After a significant decrease in C-reactive protein the regimen was changed to oral antibiotics, which were given for further 6–12 weeks. Initial antibiotic treatment consisted of a combination of clindamycin and ceftazidime or ceftriaxone and was modified depending on the sensitivity of the isolated organisms. In three patients with tuberculous infection a combination of isoniazid, pyrazinamide, ethambutol and rifampicin was administered for 4 months and a combination of isoniazid and rifampicin for a further 4 months. The duration of postoperative bed rest averaged 14 days (range 7–26 days). This delay in patient mobilisation was due to either severe illness of the patients, substantial neurological deficits or severe osteoporosis with the need for brace application. Eight patients were mobilised without any external support and 12 patients wore a brace for between 3 and 6 months postoperatively.

Radiographic data

Frontal plane deformity was minimal, measuring 3.8° (0–12°) on average preoperatively and was corrected to 1.8° (0–8°) postoperatively and measured 2.0° (0–12°) at latest follow-up. Local kyphosis was corrected from 9.2° (–20° to 64°) by 9.4° to –0.2° (–32° to 40°) postoperatively and lost 0.9° during follow-up (Table 3). The kyphosis angle at fusion levels was corrected by 7.2° on average and lost 2.2° during follow-up, leaving a final correction of 5.0°. In cases of midthoracic involvement, thoracic kyphosis was corrected from 66.0° (62–68°) to 56.0° (50–62°) at follow-up. In cases of thoracolumbar involvement, the thoracolumbar junction remained nearly unchanged during follow-up (11.6° preoperatively and 12.0° at final follow-up); and in cases of lumbar involvement the lumbar lordosis was corrected from –23.9° (–48° to 4°) to –32.0° (–52° to14°) at follow-up.

At follow-up slight lucencies around the pedicle screws were found in seven patients, with predominantly the distal screws being involved (L5 and S1). There were no screw

Table 3 Radiometric data. Patients 15, 18 and 19 died during follow-up without sufficient radiographic follow-up

Patient no.	Level of infection	Local kyphosis[a]			Fusion levels	Kyphosis at fusion levels[a]		
		Preop.	Postop.	Follow-up		Preop.	Postop.	Follow-up
1	L1/2	10°	5°	8°	T12–L3	2°	4°	6°
2	L1/2	10°	4°	6°	T12–L3	2°	–2°	6°
3	L4/5	–14°	–20°	–24°	L4–L5	–14°	–20°	–24°
4	L4/5	8°	2°	6°	L3–S1	–12°	–22°	–16°
5	T12–L2	16°	8°	10°	T11–L5	–12°	–16°	–10°
6	L2–L4	2°	–14°	–10°	T12–L5	–12°	–16°	–10°
7	L2–L5	15°	–6°	–4°	L1–L5	–19°	–22°	–22°
8	L2–L4	–18°	–32°	–28°	L1–L5	–40°	–54°	–52°
9	L2–L4	14°	–8°	–12°	T12–L5	2°	–14°	–16°
10	L2/3	10°	–18°	–16°	L1–L4	–18°	–32°	–28°
11	L2–L4	–20°	–18°	–22°	L1–L5	–48°	–42°	–42°
12	T5–T9	64°	40°	42°	T3–T11	74°	58°	58°
13	L2–L4	0°	0°	0°	L1–L5	–18°	–22°	–20°
14	T10/11	10°	4°	4°	T8–L1	14°	10°	12°
16	T4–T6	42°	32°	34°	T1–T8	60°	50°	54°
17	T6–T9	28°	16°	18°	T4–T11	56°	44°	46°
20	T12–L2	6°	2°	2°	T10–L3	2°	0°	0°

[a]Minus indicates lordotic angle

pull-outs or any cage dislocation, migration or obvious subsidence. All cage–bone interfaces appeared fused at the follow-up X-rays without any visible lucent lines. Bony incorporation appeared complete in nine and incomplete in eight patients at follow-up (Figs. 1, 2).

Complications

There was one case of intraoperative injury of the common iliac vein which had to be repaired with high intraoperative blood loss (9600 ml). In one patient (number 4) the cage had to be revised because it had been placed too far posterolaterally with L5 root compression. Despite early revision the patient sustained a mild but persistent one-sided weakness of the foot extensor muscles (rated 4 on a 5-step scale). In patient number 16 (thoracic lesion, T1–T8 fusion with primary supralaminar hooks at the top) neurological function deteriorated from Frankel B preoperatively to Frankel A postoperatively. Immediate revision and exchange of the supralaminar hooks for transverse hooks lead to a full recovery (Frankel E at follow-up). Four patients required superficial debridement and closure of the posterior wound on average 3 weeks postoperatively due to delayed wound healing. There were no deep wound infections or persistent or recurrent spinal infections.

Discussion

In the present study 20 patients with destructive vertebral osteomyelitis were surgically treated with one-stage posterior instrumentation and fusion and anterior debridement, decompression and anterior column reconstruction using an expandable titanium cage filled with morsellised autologous bone graft. At follow-up, all cages appeared solidly fused on conventional X-rays. There were no cases of cage dislocation, migration or obvious subsidence. The infection was eradicated in all patients without further anterior revision surgeries.

In the past the role of spinal instrumentation in the presence of infection has been critically discussed. For decades the gold standard has been an anterior debridement and in-situ fusion [9, 10, 13, 16]. However, an increasing number of studies advocate a combination of posterior stabilisation and anterior debridement and interbody fusion. The advantages of this technique are better correction of the kyphotic deformity and its maintenance, and earlier patient mobilisation [1, 5, 7, 8, 11, 14, 15, 19].

The use of anterior implants in vertebral osteomyelitis has only been reported by a few authors. Eysel et al. published a series of 23 patients with vertebral osteomyelitis who were treated with anterior debridement and anterior dual rod instrumentation [4]. The infection was eradicated in all cases and there were no implant-related complications. The authors conclude that even in the presence of florid vertebral osteomyelitis, anterior instrumentation is effective and eliminates the need for a posterior approach. Yilmaz et al. [21] presented their results of anterior instrumentation in 22 patients with spinal tuberculosis. The infection was eradicated in all cases, and the authors found anterior instrumentation to be more effective in correcting the deformity and stabilising the spine. However, *Mycobacterium tuberculosis* is known to be less adhesive to foreign bodies (e.g. spinal implants) than other bacteria, so it is important to distinguish between pyogenic and tuberculous vertebral osteomyelitis when discussing metallic implants in the presence of infection [14].

Sundararaj et al. [19] reported on 16 patients with tuberculosis of the spine who were surgically treated with anterior debridement and fusion using a titanium mesh cage and posterior stabilisation. The infection was eradicated in all cases. The authors found a lower incidence of graft-related problems compared to a group of anteriorly fused patients in whom tricortical iliac crest grafts had been used. In the latter group (*n*=61), graft complications such as subsidence, collapse or fracture were found in 8% of the patients.

In the current literature there is only one publication describing the use of cages in the surgical treatment of pyogenic vertebral osteomyelitis. Hee et al. [8] reported on four cases of vertebral osteomyelitis treated with posterior instrumentation and anterior debridement and interbody fusion with a titanium mesh cage. The infection was eradicated in all cases and all cages fused without any significant loss of correction at an average follow-up of 39 months.

The treatment of advanced spinal osteomyelitis follows the same principles as for any other infection of bone. It consists of rigid stabilisation and radical debridement followed by biomechanically sound reconstruction of the defect. Anterior column reconstruction can be carried out with either a structural graft (autologous tricortical iliac crest or fibula graft or structural allograft) or a cage. Expandable cages have the advantage of a primary stable anchorage and avoidance of the donor site morbidity that occurs with structural autologous bone graft harvesting. Both the present study and studies by other authors have demonstrated that the use of metallic implants in an infected area of the spine does not lead to persistence or recurrence of the infection [4, 8, 19, 21]. In addition to stabilisation of the spine, the good perfusion of the vertebral bodies and adequate soft tissue coverage of the anterior thoracolumbar spine (including immunologically active structures such as the peritoneum) are regarded as the main factors contributing to the success of this technique [4, 12]. However, prior to cage insertion, a thorough surgical debridement of all infected and necrotic tissue is mandatory and appropriate antimicrobial therapy must be administered.

Conclusion

In cases of vertebral osteomyelitis with severe anterior column destruction the use of titanium cages in combination with posterior instrumentation is effective and safe and offers a good alternative to structural bone grafts. Further follow-up is necessary to confirm these early results.

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